FORCED AIR WARMING SYSTEM

PROTOTYPE III

PERFORMANCE ENHANCING MODIFICATIONS

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DRDC Toronto CR 2002-060

FORCED AIR WARMING SYSTEM – PROTOTYPE III
PERFORMANCE ENHANCING MODIFICATIONS

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On behalf of
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EXECUTIVE SUMMARY

Mustang Survival Corporation was contracted by DRDC-Toronto to design and construct modifications for the Forced Air Warmer (FAW) System that was delivered to fulfill a previous TIES tasking, W7711-8-7479/01-SRV, Order Number 7479-5. The intent of the FAW design modifications was to enhance the performance of the system, particularly with respect to airflow from the air distribution manifolds and leakage from the component interfaces. The following tasks were completed in order to meet the requirements of the tasking:

- Redesigned the air distribution system, reducing the number of holes to 200 (89 Upper Manifold, 111 Lower Manifold), fitting each hole with a grommet and tested the system to meet the requirement for an average flow pressure of 2.2 to 2.5 in H_2O;
- Replaced fabric flow-dividing tunnel on the lower air distribution manifold with a 4-way rigid ABS connector;
- Modified the Torso Dome, Suspension and Lower Insulation Blanket (LIB) components to implement Hook and Loop fastener attachment design for sealing the microenvironment against leakage;
- Added Hook and Loop fastener to the Torso Dome foot end flap and to the passive Leg Insulation component to improve the interface;
- Provided "witness" tabs to indicate the locations where the Hook and Loop fasteners are intended to meet to seal the Torso Dome and Suspension components;
- Constructed a new LIB component to facilitate changes to the Torso Dome, Suspension and LIB interface;
- Provided a slot in the top of the Torso Dome so that a medic may perform CBR on a subject while the FAW is in use;
- Developed foam kneeling pads to be used by a medic performing CPR on a subject;
- Added Hook and Loop fastener to the Leg Suspension and Leg Insulation components to prevent the Leg Insulation from sliding when installing a subject;
- Marked the Stokes litter to identify the intended Torso Dome attachment location;
- Provided strap for securing the Electronics Box in the Stokes litter;
- Replaced the high-pressure air hose universal joint with a Delrin/Brass U-joint; and

- Replaced the plastic buckles on the Restraint System with parachute-type buckles equivalent to the one used on the shoulder harness previously.

INTRODUCTION

Under a tasking from DRDC-Toronto, W7711-017717/001/TOR, Order Number 7717-01, Mustang Survival developed modifications to enhance the performance of the FAW III system.

It is crucial to the performance of the FAW system that high flow rates are available from the air distribution manifolds. Re-warming of the subject is highly dependent on the velocity of airflow at the skin surface and hence the thickness of the boundary air layer. In addition, as a field use device the FAW must operate with as low power consumption as possible. This is achieved by insulating the microenvironment against the conditions of the external environment and by sealing to prevent leakage of the heated air. Emergency access to the subject must also be accommodated without a complete loss in thermal protection from the external environment.

This intent of this informal report is to provide a brief description of the design changes that were incorporated to fulfill the statement of work (SOW).

FAW DESIGN CHANGES

The following section outlines each of the design changes that were developed as part of this project.

Air Distribution System

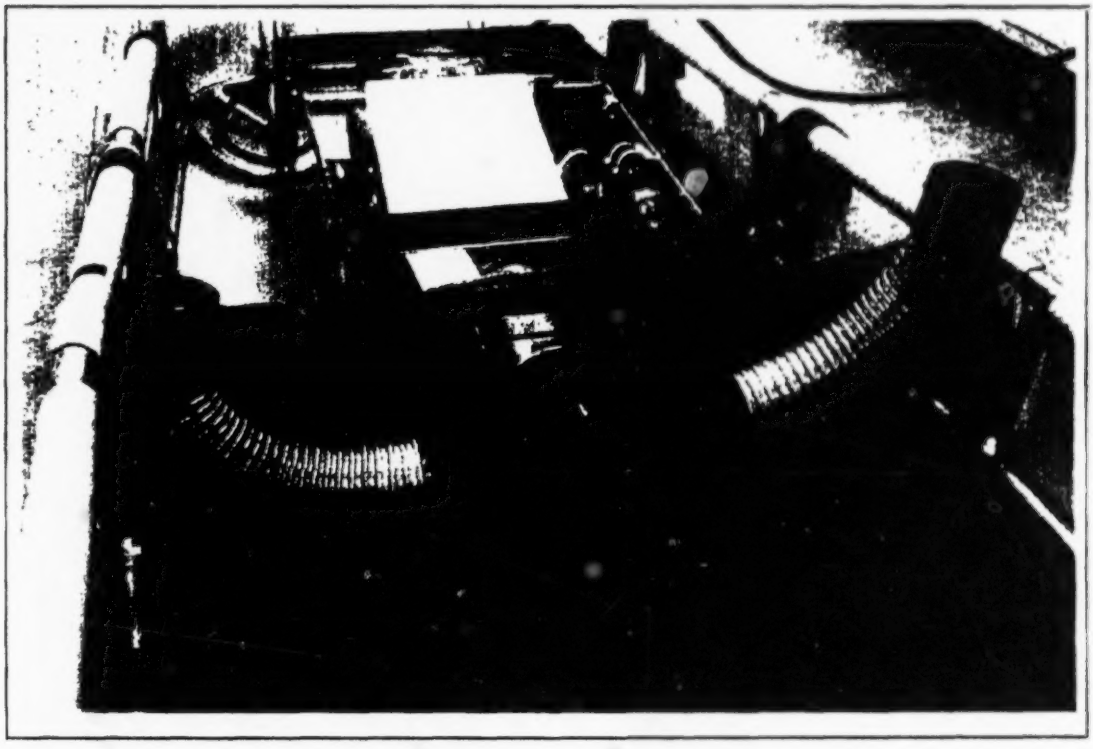
The following criteria were provided by DRDC-Toronto for redesign of the Air Distribution System:

- Must contain 200 holes: about 90 on the Upper Manifold and about 110 on the Lower Manifold;
- The diameter of the holes must be 0.172 inch;
- Holes must be fitted with grommets; and
- The air pressure from the holes must no be below about 2.2 to 2.5 inches H_2O.

The number of holes in the air distribution manifolds was decreased to meet the requirements as specified in the SOW. In order to accomplish this task, many holes were eliminated and the spacing of the holes was altered. Specifically, holes in the Lower Air Manifold located at the head end of the device that did not contribute significantly to airflow around the head were removed. Minor modifications were made to the air distribution manifolds in terms of the actual shape. The primary flow improvements were achieved by reducing the total number of holes and implementing a new design for the air distribution inlet and flow-dividing region.

On the original FAW III prototype, the airflow from the blower was divided to the Lower and Upper Manifolds by means of a RF-welded, fabric, branched duct. This fabric duct was susceptible to high flow restriction causing significant pressure losses within the system. An ABS "Double-Y" joint was purchased and used to divide the flow. In this way the ducts that connect the air distribution manifolds are non-collapsible along the

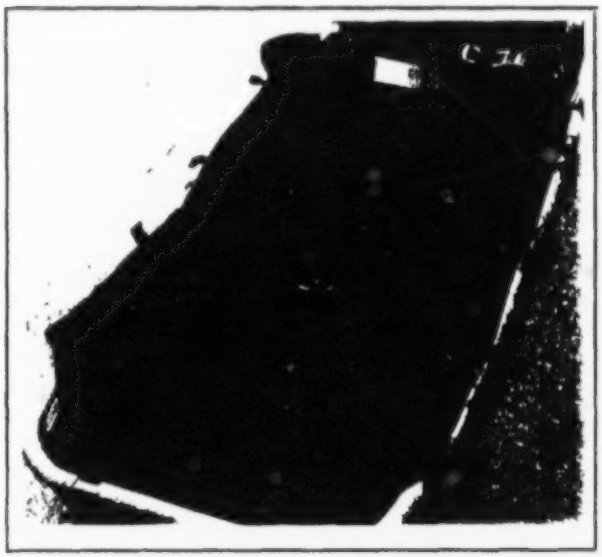
entire length. The figure below shows the ABS connector, connected to the blower outlet, the Lower Manifold and the two hoses that connect to the Upper Manifold. In addition, to prevent kinks and pressure losses in the Upper Manifold a coil spring was routed through the inlet region to prevent collapse of the duct. The average flow pressure of the Air Distribution system was tested and verified to be 2.2 inches H_2O. The test results are attached at the end of this report as Appendix A.



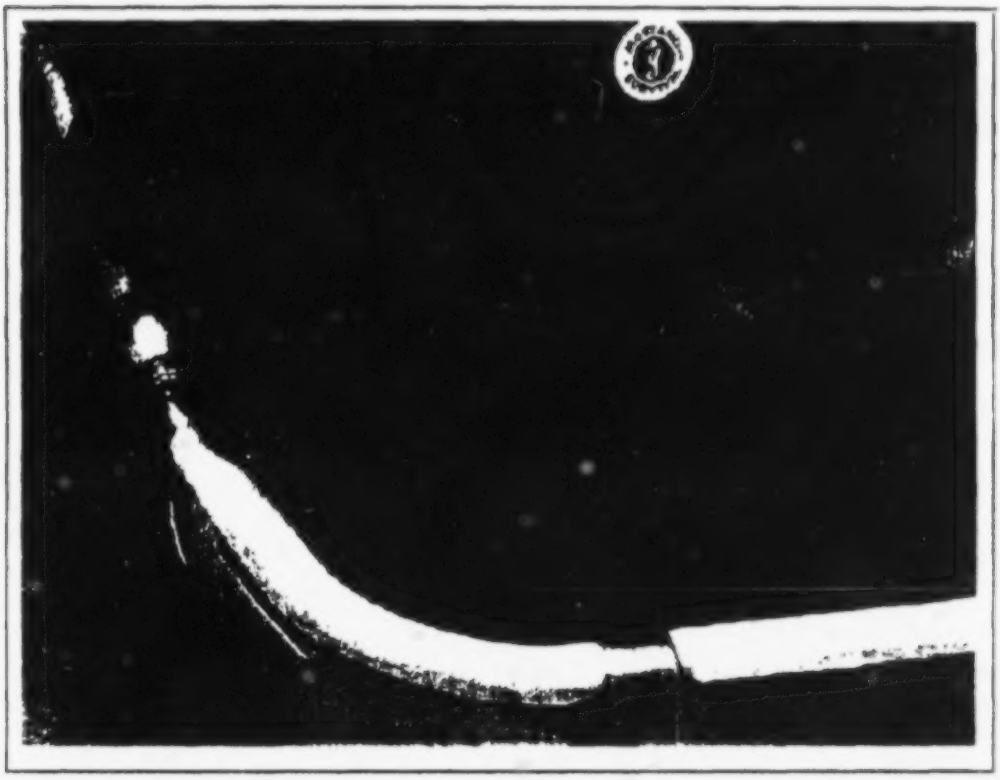
Microenvironment Enclosure Modifications

The Torso Dome, Suspension and LIB components were modified to reduce the amount of air leakage that was inherent in the initial FAW III prototype. An installation technique using Hook and Loop fastener was developed to mate the components. The FAW III LIB consisted of a foam extension that was intended to curve under the side rails of the

suspension system and seal against leakage. However, during testing it was discovered that the foam does not maintain its rigidity after any amount of prolonged use and consequently a poor seal was achieved. To resolve this problem an insulated flap was sewn to the bottom of the outermost, longitudinally running webbing on the suspension system and along the outermost transverse webbing at the head end. A new LIB was constructed, eliminating the foam extension, and Loop fastener tape was installed on the LIB along the entire perimeter of the microenvironment enclosure portion. Hook fastener sewn to the insulated flap is used to mate the Suspension and LIB components around the entire perimeter.



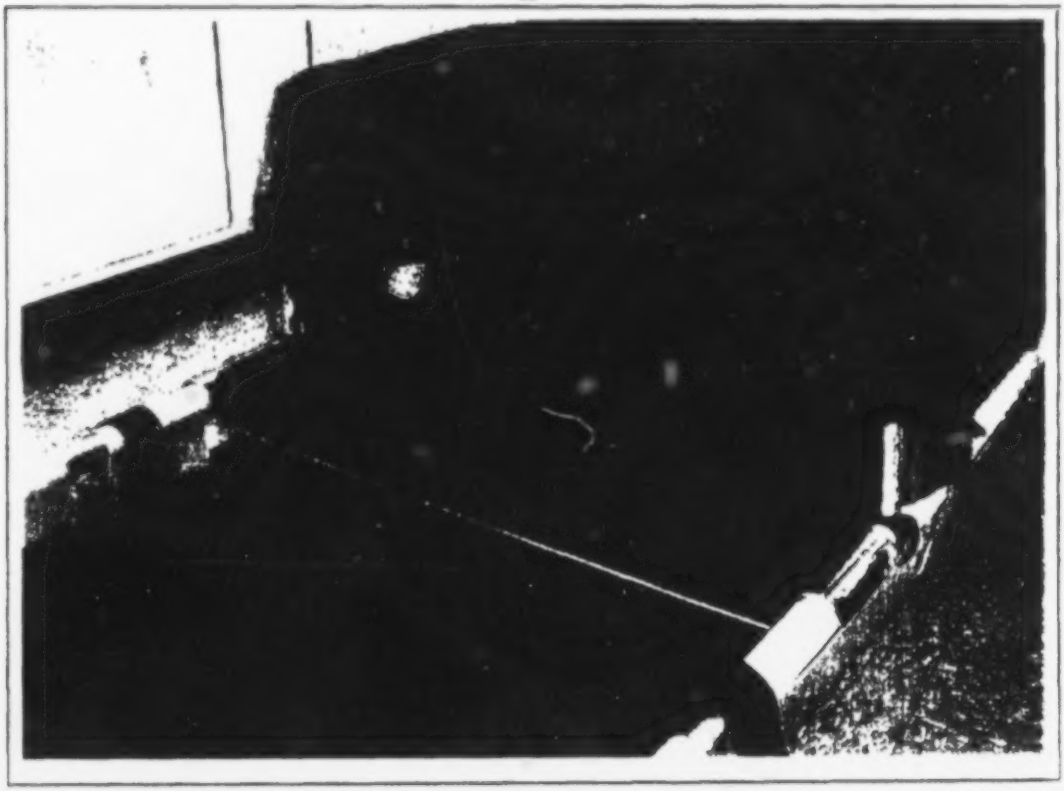
Similarly, an insulated flap was sewn to the topside of the same outermost webbings as identified above (shown in Figure at left). This flap has loop fastener sewn along the entire perimeter. The foam blocks that were previously installed in the Torso Dome "skirt" were removed and Hook fastener was installed along the entire perimeter including the hood portion. In this way the Torso Dome and Suspension may be fastened together along the entire perimeter to prevent leakage between the two components. Witness tabs are provided on the components to indicate alignment of the interface. The figure below shows the mating of the Hood portion of the Torso Dome to the Suspension system. In addition to these changes Hook and Loop fastener was added to the Torso Dome's foot end flap and the Leg Insulation component to improve mating at this interface.



CPR Modifications

The Torso Dome component was modified in order to meet the requirement that a medic could perform CPR on a subject while the FAW is in use. While performing CPR on a subject in the FAW, a medic would kneel over the subject in the Stokes litter. Two slots were incorporated into the top of the Torso Dome component (and

likewise, the Upper Air Distribution Manifold) in order to allow a medic to put his/her arms through the dome and onto the patients chest/sternum. When not in use a flap covers the slot to prevent leakage of heated air from the microenvironment. Foam cushioned kneeling pads were constructed to accommodate kneeling of the medic in the stretcher. The cushions are attached to an aluminum sheet that rests on the frame of the Stokes litter and passed beneath the legs of the subject. To reduce the weight of the kneepad system slots could be milled out of the aluminum sheet. The figure below shows the kneeling pads installed in the FAW system.



Miscellaneous Modifications

The complementary design modifications that were conducted as part of this project are described below.

Leg Insulation & Leg Suspension

The technical authority indicated that it was desirable to prevent the Leg Insulation component from sliding on the Leg Suspension component when laying a subject into the FAW system. Hook and Loop fastener strips were sewn to the Leg Insulation and the Leg Suspension respectively to provide a method of non-aggressive attachment.

Markings

The technical authority indicated that it is difficult to determine at what location the Torso Dome component should be installed on the Stokes litter. Markings were added to the plastic shell of the Stokes litter to indicate the location at which the Torso Dome flashlight clips should be attached.

Electronics Box

A strap was provided to prevent the Electronics Box from inadvertent movement during transport.

Universal Joint

The upper body (torso) and lower body (leg) components of the suspension system were originally connected using a length of high-pressure air hose as a universal joint. In terms of aesthetics and durability the air hose was deficient. Delrin/Brass universal joints were purchased and were substituted in the design as a component of this project. The universal joints were purchased from W. M. Berg, Inc. (UJS-10, Single Commercial Universal Joint, $13.66 US each).

Restraint (Harness) System

The restraint (harness) system is intended to secure the subject in the FAW during transportation. This includes and is not limited to carrying, transport on a wagon or vehicle, slings for helicopter lift and traversing steep inclines or declines. Consequently, the plastic buckles on the original FAW III restraint system were determined to be deficient in terms of breaking strength. These were replaced with metal buckles that were purchased from the Para-Gear Equipment Company, Inc. (www.para-gear.com) (H431 & H427, Survival Kit Lock Release & Accessory Ring, Tensile Strength: 500 pounds, $29.50 US & $4.00 US each respectively). Additional verification is required to determine whether or not the new metal buckles meet load-bearing requirements for a Stokes litter Restraint System.

CONCLUSION

Modifications were designed and implemented in order to improve the performance of the FAW III prototype system. The Air Distribution System was tested to meet the requirements that developed by DRDC-Toronto during testing of the initial prototype system (2.2 inches H_2O). The Torso Dome, Suspension and LIB components were modified to incorporate an attachment system using Hook and Loop fastener to effectively seal against leakage. This design change has reduced the leakage from the FAW microenvironment significantly. The modification of the Torso Dome component to include arm slots will allow a medic to have emergency access to a subject in order to provide emergency medical assistance such as CPR. Additionally, several minor complementary modifications were provided for the FAW system. This FAW III Modifications project has resulted in significant performance and aesthetic improvements over the initial FAW III prototype. To best incorporate the design changes, additional testing and validation of the prototype is required. Following validation of the prototype performance, a final prototype version of the FAW III should be constructed to accurately represent all of the FAW III design features for future construction.

APPENDIX A

Air Distribution Test Results

The new design of the air distribution system was tested to determine whether or not the performance requirements would be met. The system was installed in the new LIB and the modified Torso Dome, which were both installed in the Stokes litter in the preferred orientation (the as designed and delivered configuration). The goal of the design changes was to achieve an average flow pressure of 2.2 to 2.5 inches H_2O. With the blower set at full speed, a Digitron Model P100M Pressure Measurement Instrument was used to determine the flow pressure at each hole. The results are shown in the table below.

Air Distribution Test Results

Average Pressure (Number of Holes)		
	Upper Manifold [in H_2O]	**Lower Manifold [in H_2O]**
Center Column	2.1 (31)	3.4 (43)
Left & Right Columns	2.1 (58)	1.5 (68)
Total Weighted Average [in H_2O]		**2.2**

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14 ABSTRACT

(U) Mustang Survival Corporation was contracted by DRDC-Toronto to design and construct modifications for the Forced Air Warmer (FAW) System that was delivered to fulfill a previous TIES tasking, W7711-8-7479/01-SRV, Order Number 7479-5. The intent of the FAW design modifications was to enhance the performance of the system, particularly with respect to airflow from the air distribution manifolds and leakage from the component interfaces. The following tasks were completed in order to meet the requirements of the tasking:

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(U) rewarming, field treatment, active rewarming, hypothermia